January 1993

Chemistry 30

Grade 12 Diploma Examination

Alberta
EDUCATION

January 1993

Chemistry 30

Grade 12 Diploma Examination

Description

Time allotted: 2.5 h
Total possible marks: 70

This is a **closed-book** examination consisting of **three** parts:

Part A
has 42 multiple-choice questions each with a value of one mark.

Part B
has 7 numerical-response questions each with a value of one mark.

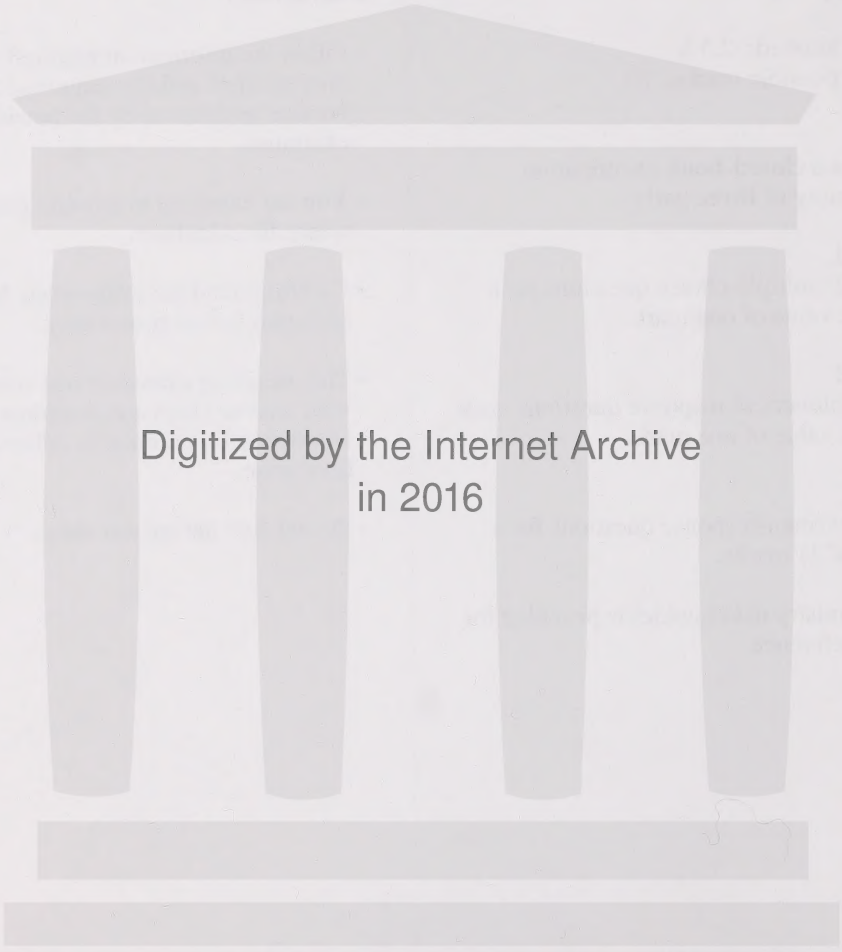
Part C
has 3 written-response questions for a total of 21 marks.

A chemistry data booklet is provided for your reference.

Instructions

- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- You are expected to provide your own scientific calculator.
- Carefully read the instructions for each part before proceeding.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Do not fold the answer sheet.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work.* ***No marks*** *will be given for work done on the tear-out pages.*



Part A: Multiple Choice

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully and decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

Example

This diploma examination is for the subject of

A. biology
B. physics
C. chemistry
D. mathematics

Answer Sheet

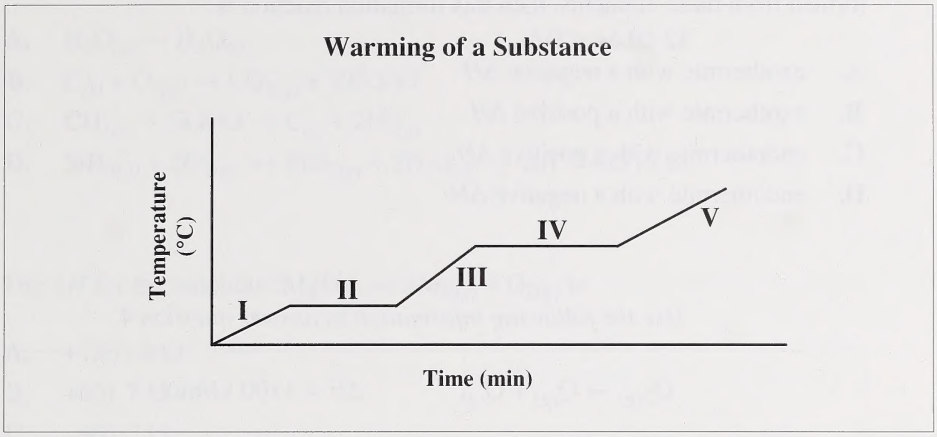
Ⓐ Ⓑ ● Ⓓ

- **Use an HB pencil only.**
- If you wish to change an answer, erase **all** traces of your first answer.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work.* ***No marks*** *will be given for work done on the tear-out pages.*

Do not turn the page to start the examination until told to do so by the presiding examiner.

Use the following diagram to answer question 1.



1. The sections of the diagram where the substance exists in two phases are

A. I and III
B. II and IV
C. III and V
D. I and V

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2. When 1.00 g of water as steam at 100°C condenses to liquid at 100°C,

A. the potential energy increases for the water
B. the average kinetic energy decreases for the water
C. the average kinetic energy remains the same for the water
D. both the potential and kinetic energies decrease for the water

3. If the potential energy of elements is **less** than the potential energy of the compound formed from these elements, then this formation reaction is

A. exothermic with a negative ΔH

B. exothermic with a positive ΔH

C. endothermic with a positive ΔH

D. endothermic with a negative ΔH

Use the following information to answer question 4.

$Q_{2(g)} \rightarrow Q_{(g)} + Q_{(g)}$	$\Delta H = +100$ kJ/mol
$X_{2(g)} \rightarrow X_{(g)} + X_{(g)}$	$\Delta H = +50$ kJ/mol
$Q_{(g)} + X_{(g)} \rightarrow QX_{(g)}$	$\Delta H = -200$ kJ/mol

4. If $Q_{2(g)}$ reacted with $X_{2(g)}$ to form $QX_{(g)}$, the statement that would **best** describe this reaction is that

A. intramolecular bonding in sample $X_{2(g)}$ is stronger than in $Q_{2(g)}$

B. intermolecular bonding in sample $X_{2(g)}$ is weaker than in $Q_{2(g)}$

C. the reaction is endothermic

D. the reaction is exothermic

---

5. Which of these reactions is a formation reaction?

A. $HCl_{(aq)} + NaOH_{(s)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$

B. $Zn_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow ZnO_{(s)}$

C. $2Ag^{+}_{(aq)} + Mg_{(s)} \rightarrow Mg^{2+}_{(aq)} + 2Ag_{(s)}$

D. $SO_{2(g)} + H_2O_{(l)} \rightarrow H_2SO_{3(aq)}$

6. Which equation represents an endothermic chemical change?

A. $H_2O_{(s)} \rightarrow H_2O_{(l)}$ $\Delta H = +6.03$ kJ

B. $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} + 393.5$ kJ

C. $CH_{4(g)} + 74.8$ kJ $\rightarrow C_{(s)} + 2H_{2(g)}$

D. $SiH_{4(g)} + 2O_{2(g)} \rightarrow SiO_{2(g)} + 2H_2O_{(l)}$ $\Delta H = -1516$ kJ

7. The ΔH for the reaction $2MgO_{(s)} \rightarrow 2Mg_{(s)} + O_{2(g)}$ is

A. +1203.4 kJ

B. +601.7 kJ

C. −601.7 kJ

D. −1203.4 kJ

8. Which change releases the greatest amount of energy?

A. $2\,{}^{2}_{1}H \rightarrow {}^{4}_{2}He$ + energy

B. $H_2O_{(g)} \rightarrow H_2O_{(l)}$ + energy

C. $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$ + energy

D. $H_2SO_{4(aq)} + 2NaOH_{(s)} \rightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$ + energy

9. Water has a specific heat capacity of 4.19 J/g•°C, and glass has a specific heat capacity of 0.74 J/g•°C. When water is heated slowly for 10.0 min in a glass container, the

A. water absorbs more heat per gram and has a higher final temperature than the glass

B. water absorbs more heat per gram and has the same final temperature as the glass

C. glass absorbs more heat per gram and has a higher final temperature than the water

D. glass absorbs more heat per gram and has the same final temperature as the water

10. The ΔH for the reaction $3Fe_{(s)} + 4H_2O_{(g)} \rightarrow Fe_3O_{4(s)} + 4H_{2(g)}$ is

A. +24.8 kJ
B. –151.2 kJ
C. –832.6 kJ
D. –876.6 kJ

11. A student completely burned a small candle and found that burning the candle warmed 50 g of water from 20°C to 26°C. If the student were to repeat the experiment using an identical candle and, this time, 150 g of water at 20°C, the expected final temperature of the water would be

A. 21°C
B. 22°C
C. 23°C
D. 24°C

12. A student designed a calorimetric experiment to determine the molar heat of combustion of paraffin, $C_{25}H_{52}$. After performing the experiment, the student recorded these data:

mass of $Al_{(s)}$ calorimeter	6.0 g
mass of water and calorimeter	400.0 g
initial temperature of water	20.0°C
final temperature of water	35.5°C
initial mass of candle	25.7 g
final mass of candle	23.5 g

Based on these data, the molar heat of combustion of paraffin is

A. –0.35 MJ/mol
B. –0.38 MJ/mol
C. –4.1 MJ/mol
D. –4.2 MJ/mol

13. Which property applies to a 0.10 mol/L solution of strong base?

A. High pH
B. Tastes sour
C. Weak electrolyte
D. Turns blue litmus to red

14. A solution contains more hydrogen ions than hydroxide ions. Such a solution

A. is neutral
B. has a high pH
C. is a nonelectrolyte
D. turns phenol red to yellow

15. The equation $HCl_{(aq)} \rightarrow H^{+}_{(aq)} + Cl^{-}_{(aq)}$ illustrates the

A. Arrhenius concept of acids
B. Arrhenius concept of bases
C. Brønsted-Lowry concept of acids
D. Brønsted-Lowry concept of bases

16. Which of these pairs is a conjugate pair?

A. $H_3O^{+}_{(aq)}$, $OH^{-}_{(aq)}$
B. $NH_4{}^{+}_{(aq)}$, $NH_{3(aq)}$
C. $H_3O^{+}_{(aq)}$, $HSO_4{}^{-}_{(aq)}$
D. $H_3PO_{4(aq)}$, $HPO_4{}^{2-}_{(aq)}$

17. Which 0.1 mol/L solution would have the highest electrical conductivity?

A. $CH_3COOH_{(aq)}$
B. $H_2SO_{4(aq)}$
C. $CO_{2(aq)}$
D. $NH_{3(aq)}$

18. The hydronium ion concentration in 100 mL of 0.10 mol/L hydrofluoric acid at 25°C is

A. 0.10 mol/L
B. 0.078 mol/L
C. 0.010 mol/L
D. 0.0078 mol/L

19. When 12.2 g of $Sr(OH)_{2(s)}$ are dissolved and dissociated completely to make 4.0 L of aqueous solution, the pH of the solution is

A. 12.70
B. 12.40
C. 1.60
D. 1.30

20. When phenolphthalein is added to a solution with a pH of 4, the resulting solution is

A. pink
B. blue
C. colorless
D. yellow

21. A solution containing thymol blue is red-colored. When another solution is added, the resulting solution is blue. This color change occurs because

A. an acid was added to a base

B. a base was added to an acid

C. another indicator may have been present

D. a strong base was added to a weak base

22. The balanced net ionic equation for the reaction that occurs when ethanoic acid is mixed with aqueous sodium hydroxide is

A. $CH_3COOH_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)} \rightarrow CH_3COO^-_{(aq)} + H_2O_{(l)} + Na^+_{(aq)}$

B. $CH_3COOH_{(aq)} + OH^-_{(aq)} \rightarrow CH_3COO^-_{(aq)} + H_2O_{(l)}$

C. $CH_3COO^-_{(aq)} + H^+_{(aq)} + OH^-_{(aq)} \rightarrow CH_3COO^-_{(aq)} + H_2O_{(l)}$

D. $CH_3COOH_{(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaCH_3COO_{(aq)}$

23. An acid-base reaction that favors the formation of products is

A. $HF_{(aq)} + HCO_3^-{}_{(aq)}$

B. $H_2CO_{3(aq)} + NO_2^-{}_{(aq)}$

C. $H_2S_{(aq)} + SO_4^{2-}{}_{(aq)}$

D. $H_2SO_{3(aq)} + HOOCCOO^-{}_{(aq)}$

24. 47.0 mL of a monoprotic acid solution neutralizes 56.0 mL of 0.010 mol/L $Ba(OH)_{2(aq)}$. This monoprotic acid solution also causes methyl orange to turn red and causes orange IV to turn yellow. What is the per cent dissociation of this acid?

A. 0.89%

B. 2.1%

C. 3.0%

D. 4.2%

25. Which is the **best** statement about color changes in acid-base titrations that involve indicators?

A. Bases change color when they accept protons from indicators.
B. Acids change color when they donate protons to indicators.
C. Indicators change color when they accept protons from bases.
D. Indicators change color when they donate protons to bases.

26. When 50.0 mL of 1.00 mol/L $HCl_{(aq)}$ are added to 50.0 mL of 1.00 mol/L $NaOH_{(aq)}$, the amount of energy released is 2.9 kJ. If, instead, 100.0 mL of 1.00 mol/L $HCl_{(aq)}$ were added to 50.0 mL of 1.00 mol/L $NaOH_{(aq)}$, the amount of energy released would be

A. 1.5 kJ
B. 1.9 kJ
C. 2.9 kJ
D. 5.8 kJ

27. Which oxidizing agent can act as a Brønsted-Lowry base?

A. $AgBr_{(s)}$
B. $Ag^{+}_{(aq)}$
C. $Cl_{2(g)}$
D. $H_2O_{(l)}$

28. Which term **best** describes the reaction $H_2SO_{4(aq)} + 2KOH_{(aq)} \rightarrow K_2SO_{4(aq)} + 2H_2O_{(l)}$?

A. Endothermic
B. Neutralization
C. Oxidation-reduction
D. Net ionic

29. A substance that loses electrons is

A. the cathode
B. the oxidizing agent
C. undergoing oxidation
D. undergoing reduction

30. The unbalanced equation that represents a reduction half-reaction is

A. $X^{2+}_{(aq)} \rightarrow X^{3+}_{(aq)}$
B. $R^{2+}_{(aq)} \rightarrow R^{+}_{(aq)}$
C. $Z_{(s)} \rightarrow Z^{3+}_{(aq)}$
D. $2R^{-}_{(aq)} \rightarrow R_{2(aq)}$

31. In the reaction $2Ag^{+}_{(aq)} + Cu_{(s)} \rightarrow 2Ag_{(s)} + Cu^{2+}_{(aq)}$, the silver ion is

A. oxidized
B. losing an electron
C. the reducing agent
D. the oxidizing agent

32. The balanced net ionic equation for the most probable reaction of iron(II) chloride with acidified potassium nitrate is

A. $Fe^{2+}_{(aq)} + NO_3^{-}{}_{(aq)} + 2H^{+}_{(aq)} \rightarrow Fe^{3+}_{(aq)} + NO_{2(g)} + H_2O_{(l)}$
B. $Fe^{2+}_{(aq)} + 2NO_3^{-}{}_{(aq)} + 4H^{+}_{(aq)} \rightarrow 2NO_{2(g)} + 2H_2O_{(l)} + Fe_{(s)}$
C. $Fe^{2+}_{(aq)} + 2H_2O_{(l)} \rightarrow Fe_{(s)} + 2H^{+}_{(aq)} + O_{2(g)}$
D. $Fe^{2+}_{(aq)} + 2Cl^{-}_{(aq)} \rightarrow Fe_{(s)} + Cl_{2(g)}$

33. The substance in which nitrogen has an oxidation number of +4 is

A. $NO_{2(g)}$
B. $NO_{(g)}$
C. $N_{2(g)}$
D. $HNO_{3(aq)}$

34. Fiona prepared a standard acidified solution of $Fe^{2+}_{(aq)}$ and then titrated a $KMnO_{4(aq)}$ solution of unknown concentration. Why did Fiona acidify the $Fe^{2+}_{(aq)}$ standard solution?

A. $Fe^{2+}_{(aq)}$ cannot act as a reducing agent without acid.
B. The acid changes $Fe^{2+}_{(aq)}$ to $Fe_{(s)}$ to form the standard solution.
C. $MnO_4^-{}_{(aq)}$ will not act as an oxidizing agent without the acid.
D. Acid is required to dilute the $Fe^{2+}_{(aq)}$ to a lower concentration.

35. Zinc metal will not act as a reducing agent for which group of chemical agents?

A. $Fe^{2+}_{(g)}$, $H^+_{(aq)}$, $Cu^{2+}_{(aq)}$
B. $Co^{2+}_{(aq)}$, $Sn^{2+}_{(aq)}$, $Pb^{2+}_{(aq)}$
C. $Cu^{2+}_{(aq)}$, $Hg^{2+}_{(aq)}$, $Br_{2(l)}$
D. $Ca^{2+}_{(aq)}$, $Na^+_{(aq)}$, $Mg^{2+}_{(aq)}$

36. The mass of $I_{2(s)}$ that is formed when 800 mL of 0.100 mol/L $NaI_{(aq)}$ react with excess chlorine gas, $Cl_{2(g)}$, is

A. 10.2 g
B. 50.8 g
C. 102 g
D. 203 g

Use the following information to answer question 37.

A student made these observations after mixing several test solutions with samples of TTE (1,1,2-trichloro-1,2,2-trifluoroethane).

Solution	Color of TTE layer
$Cl^-_{(aq)}$	colorless
$Br^-_{(aq)}$	colorless
$I^-_{(aq)}$	colorless

Solution	Color of TTE layer
$Cl_{2(aq)}$	colorless
$Br_{2(aq)}$	orange
$I_{2(aq)}$	pink

She then mixed various combinations of solutions and obtained these results:

I. $Cl_{2(aq)} + Br^-_{(aq)}$: TTE layer orange
II. $Cl^-_{(aq)} + Br_{2(aq)}$: TTE layer orange
III. $I^-_{(aq)} + Br_{2(aq)}$: TTE layer pink

37. The reaction(s) that shows that bromine was produced is(are)

A. I only
B. III only
C. I and II
D. I, II, and III

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38. One of the main techniques used in quantitative measurement of redox reactions is

A. precipitation
B. titration
C. dissociation
D. neutralization

39. The $E°_{net}$ value for the reaction that takes place when $Cl_{2(g)}$ is added to a 1.0 mol/L solution of $NaI_{(aq)}$ is

A. –1.90 V
B. –0.82 V
C. +0.82 V
D. +1.90 V

40. Students tried the following combination of reactants in a laboratory. Which combination is expected to be nonspontaneous?

A. $Ag^{+}_{(aq)} + H_{2(g)}$
B. $Cr_{(s)} + Sn^{2+}_{(aq)}$
C. $Ba_{(s)} + Fe^{2+}_{(aq)}$
D. $Al_{(s)} + Ca^{2+}_{(aq)}$

41. Which statement about electrochemical cells is **false**?

A. $E°_{net}$ is positive.
B. Oxidation occurs at the anode, reduction at the cathode.
C. Electrochemical cells convert electrical energy to chemical energy.
D. Electrons flow, in the external circuit, from the anode to the cathode.

42. A student decided to produce some sodium metal by electrolyzing an aqueous solution of sodium chloride. Why was this venture doomed to failure?

A. $H_2O_{(l)}$ is oxidized faster than $Cl^{-}_{(aq)}$.
B. The $Na_{(s)}$ formed would react with water.
C. $H_2O_{(l)}$ is reduced more readily than $Na^{+}_{(aq)}$.
D. $Cl^{-}_{(aq)}$ is reduced more readily than $Na^{+}_{(aq)}$.

You have now completed Part A. Proceed directly to Part B.

Part B: Numerical Response

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully.
- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- **Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**
- Use an HB pencil only.
- If you wish to change an answer, erase **all** traces of your first answer.

Sample Calculation Question and Solution

The mass in grams of silver produced when 0.220 mol of silver nitrate reacts with exceess copper is _____ g.
(Record your answer to three digits.)

$$\text{mass}_{Ag} = 0.220 \text{ mol} \times 107.87 \text{ g/mol}$$
$$= 23.7314 \text{ g}$$
$$= 23.7 \text{ g (rounded to three digits)}$$

Record 23.7 on the answer sheet →

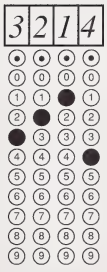
Sample Correct-order Question and Solution

When the following subjects are arranged in alphabetical order, the order is _____.
(Record all four digits.)

1. mathematics
2. chemistry
3. biology
4. physics

Answer 3, 2, 1, 4

Record 3214 on the answer sheet →



Start Part B immediately.

1. The heat of formation for 1.00 mol of $NO_{2(g)}$ is _____ kJ.
(Record your answer to three digits.)

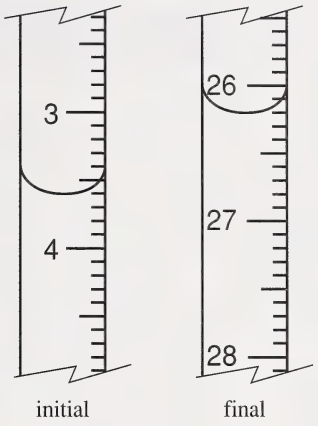
Use the following information to answer question 2.

$$PCl_{5(s)} + 2Na_{(s)} \rightarrow PCl_{3(s)} + 2NaCl_{(s)} + 729.5 \text{ kJ}$$

2. When 0.235 mol of reducing agent reacts, the heat produced is _____ kJ.
(Record your answer to three digits.)

RECORD YOUR ANSWER ON THE ANSWER SHEET

3. 10.0 mL of $NaOH_{(aq)}$ are titrated with 0.752 mol/L $HCl_{(aq)}$ from a buret, as shown on the right. The concentration of the sodium hydroxide solution is _____ mol/L. (Record your answer to three digits.)



4. The following are hypothetical reactions:

1. $H_4X_{(aq)} + CO_3^{2-}{}_{(aq)} \rightleftharpoons H_3X^-{}_{(aq)} + HCO_3^-{}_{(aq)}$
2. $HX^{3-}{}_{(aq)} + CO_3^{2-}{}_{(aq)} \rightleftharpoons X^{4-}{}_{(aq)} + HCO_3^-{}_{(aq)}$
3. $H_2X^{2-}{}_{(aq)} + CO_3^{2-}{}_{(aq)} \rightleftharpoons HX^{3-}{}_{(aq)} + HCO_3^-{}_{(aq)}$
4. $H_3X^-{}_{(aq)} + CO_3^{2-}{}_{(aq)} \rightleftharpoons H_2X^{2-}{}_{(aq)} + HCO_3^-{}_{(aq)}$

The order of these reactions, beginning with the one that forms the most product to the one that forms the least product, is _____. (Record all four digits.)

5. The oxidation number of the sulphur in each of the compounds Na_2SO_4, Na_2SO_3, SO_2, and SO_3 respectively is _____. (Record all four digits.)

6. When 1.20 mol of $H_2PO_4^-{}_{(aq)}$ react according to the equation $12H_2PO_4^-{}_{(aq)} + 12H^+{}_{(aq)} + 10Br^-{}_{(aq)} \rightarrow 3P_{4(s)} + 18H_2O_{(l)} + 10BrO_3^-{}_{(aq)}$, the number of moles of electrons transferred is _____ mol. (Record your answer to three digits.)

7. When a strip of $Fe_{(s)}$ is placed into 1.0 mol/L $HNO_{3(aq)}$, a brown gas, $NO_{2(g)}$, is produced and the iron "dissolves." The $E°_{net}$ for this reaction is _____ V. (Record your answer to three digits.)

SWER ON THE ANSWER SHEI

You have now completed Part B. Proceed directly to Part C.

Part C: Written Response

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully.
- Write your answers in the examination booklet as neatly as possible.
- For full marks, your answers **must show all** pertinent explanations, calculations, and formulas.
- Your answers **should be** presented in a well-organized and appropriate manner; for example, complete sentences for a written response, and correct units and significant digits for a numerical response.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work.* ***No marks*** *will be given for work done on the tear-out pages.*

Start Part C immediately.

For Department Use Only

(6 marks)

1. Terry performed an experiment in which she added 1.00 mol/L $HCl_{(aq)}$ to 50.00 mL of 1.00 mol/L $NaOH_{(aq)}$ and then measured the temperature of the resulting solution. The data from her experiment are tabulated below.

Volume of $HCl_{(aq)}$ (mL)	**Temperature of solution (°C)**
0.00	22.0
25.00	33.1
50.00	38.7
75.00	35.2
100.00	32.9

Use the following grid and the data supplied to answer the question on page 19.

Graph Terry's data on the grid provided on page 18. Mark with a neat "×" the point on the graph where the pH of the solution is 7. Next, use the graph to explain what happened in the experiment.

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(8 marks)

Use the following information to answer question 2.

Experiment	Substance	Molar Mass	Mass	Mass of Water Heated	Temperature Change of Water
I	a	200.0 g/mol	0.100 g	10.0 kg	75°C
II	b	25.0 g/mol	1.00 g	10.0 g	85°C
III	c	105.0 g/mol	2.00 g	1.00 kg	45°C

2. Identify which experiment corresponds to a phase change, to a chemical reaction, and to a nuclear reaction. Justify your answer by providing logical reasons and/or specific calculations for **each** identification.

3. Selected metals are often directly connected to equipment made of iron to protect the iron from corrosion.

a. Choose a metal that is both practical and suitable for this purpose and explain how the metal you chose would protect the iron.

b. For the metal you chose, determine the minimum mass you would have to attach to the iron if your metal produces an electron flow of 5.00 mA for one year. (Assume there are 365 days per year.)

You have now completed the examination.
If you have time, you may wish to check your answers.

No marks will be given for work done on this page.

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Chemistry 30
January 1993

Name

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Chemistry 30

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Chemistry 30

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M1 M2 M3 M4

Chem 30 - 931
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CHEMISTRY 30 MULTIPLE-CHOICE KEY

1.	B	22.	B
2.	C	23.	A
3.	C	24.	D
4.	D	25.	D
5.	B	26.	C
6.	C	27.	D
7.	A	28.	B
8.	A	29.	C
9.	B	30.	B
10.	B	31.	D
11.	B	32.	A
12.	C	33.	A
13.	A	34.	C
14.	D	35.	D
15.	A	36.	A
16.	B	37.	A
17.	B	38.	B
18.	D	39.	C
19.	A	40.	D
20.	C	41.	C
21.	B	42.	C

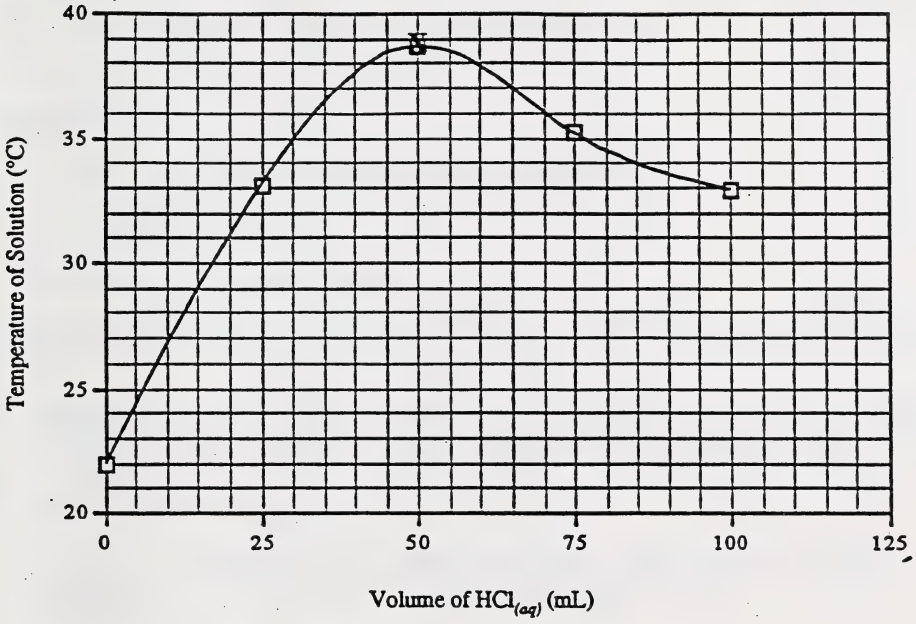
NUMERICAL RESPONSE KEY

1. 33.2
2. 85.7
3. 1.70
4. 1432
5. 6446
6. 6.00
7. 1.25

SAMPLE ANSWERS TO THE WRITTEN-RESPONSE SECTION

NOTE: The responses that follow represent ONE approach to each of the problems. During the diploma examination marking session, provision is made for considering the various approaches students may have used.

Reaction of 1.00 mol/L $HCl_{(aq)}$ with 1.00 mol/L $NaOH_{(aq)}$



1.

As $HCl_{(aq)}$ is added, energy is released when the $HCl_{(aq)}$ reacts with $NaOH_{(aq)}$ which results in an increase in temperature. This continues until no further reaction is possible due to the comsumption of $NaOH_{(aq)}$. This shows on the graph as a steady increase. When there is no more $NaOH_{(aq)}$ to react, the addition of $HCl_{(aq)}$ cools the solution, thus the graph slopes downwards.

SAMPLE ANSWERS TO THE WRITTEN-RESPONSE SECTION

2. Experiment I

$n_H = mc\Delta t$

$H = 10.0\ kg\ (4.19\ J/g°C)(75°C)(200\ g/mol/0.100\ g)$

$= 6.3 \times 10^6\ kJ/mol$

Experiment II

$H = 0.0100\ kg\ (4.19\ J/g°C)(85°C)(25.0\ g/mol/1.00\ g)$

$= 89.0\ kJ/mol$

Experiment III

$H = 1.00\ kg\ (4.19\ J/g°C)(45°C)(105\ g/mol/2.00\ g)$

$= 9.9 \times 10^3\ kJ/mol$

Since $H_{nuclear} > H_{chemical} > H_{phase}$

then Experiment I is nuclear, Experiment II is phase, and Experiment III is chemical.

3. a. Magnesium could be used to protect the iron equipment. The magnesium protects the iron by reacting in the place of iron because it is a stronger reducing agent.

b. $Mg_{(s)} \rightarrow 2e^- + Mg^{2+}_{(aq)}$

$$\text{mass Mg} = \frac{5.00 \times 10^{-3}\ J/C\ (3600\ s/h)(24h/d)(365\ d/y)(\frac{1}{2})(24.31\ g/mol)}{9.65 \times 10^4\ C/mol}$$

$= 19.9\ g/y$